The Use of X-ray and Thermal Neutrons in Producing Mutations in Rice 1/

by

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The use of X-ray and thermal neutrons is being investigated as a means of bringing about favorable mutations in rice varieties. The leading varieties grown in the United States are reasonably well adapted to the various rice growing areas and mechanized production methods. However, mutations bringing about shorter, sturdier straw, earlier maturity, disease resistance and improved milling, processing and cooking quality would be an effective means of improving these varieties.

Materials and Methods:

In 1953, foundation seed lots of Bluebonnet 50 and Century Patna 231 were sent to the Brookhaven National Laboratory, Upton, Long Island, New York, for exposure to X-rays and thermal neutrons. Seed samples of from 50 to 100 grams of each variety were exposed to 15,000, 20,000 and 25,000 r units of X-ray and 16, 20 and 25 hours of thermal neutrons.

The seed from each treated lot and untreated seed were sown at Beaumont, Texas, on May 21, 1953. Where enough were available, 100 plants were selected at random from each treatment of each variety in the fall of 1953. Four panicles were saved from each plant, if available. Seed from 75 plants of each treatment and control plants were sown in single panicle rows on June 1, 1954. By examining the progeny from four panicle rows of each plant, any bud mutations produced would have been readily distinguished.

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A large number of panicles from the 1954 panicle row test were harvested, and 950 selections were sown in single panicle rows in 1955.

Results:

First Generation

The lower rates of treatment showed little or no reduction in the number of seedlings that emerged from the soil, but as the rates of treatment increased, there was a marked reduction in seedling emergence. The 25,000 r units of X-ray resulted in a severe reduction in seedling emergence. The 25-hour thermal neutron treatment was even more severe and only an occasional plant survived.

The vegetative growth of plants from seeds receiving the lower rates of treatment appeared normal insofar as could be observed. However, weak or abnormal-appearing plants were apparent as the rates of treatment increased.

All treatments produced many sterile or partly sterile plants and the degree of sterility increased as the rates of treatment increased. Many plants were entirely sterile at the higher rates. The 25-hour neutron treatment was more severe than the 25,000 r unit X-ray treatment. A few plants produced seed in the 25-hour neutron treatment of Bluebonnet 50 but there were no seeds produced in the same treatment of Century Patna 231.

Second Generation

In the X_2 generation, time did not permit a detailed examination of all rows but casual observations were made several times during the vegetative period of growth. An occasional unusual plant was observed in the vegetative stage.

At maturity all rows were examined and panicles of the most apparent mutations were saved. Practically all of the mutations occurred as occasional plants in one or more of the four panicle rows from each X_1 plant.

In some cases a rather large number of abnormal plants were present in the rows, but for the most part the majority of the plants were near normal in appearance, except for varying degrees of sterility. A rather high degree of sterility was apparent throughout the X_2 rows with an increase in degree at the higher rates of treatment.

Third Generation

A total of 950 selections made from X_2 rows were sown in single panicle rows in 1955. This included panicles from untreated material of both varieties. Seventy-two untreated panicle rows of Century Patna 231 and 100 panicle rows of Bluebonnet 50 were sown throughout the experiment. These panicle selections were selected at random from the check rows grown in the 1954 experiment.

The types of variability observed in the X_3 rows are recorded in Table 1. The most common mutations were in plant height and grain length. Sterility was again pronounced in many of the rows, and 77 rows were recorded as carrying sterile plants of the most severe type. It was estimated that more than 50 percent of the rows probably showed abnormal sterility.

Grain Length

Occasional plants produced a longer than normal grain, but short grain mutations were more frequent. The shorter grain types were found mostly on plants of shortened mature height. Both long and short grain mutations were recovered from segregating rows in the X_2 generation.

TABLE 1 Mutations recovered from X_3 generation of Century Patna 231 and Bluebonnet 50 varieties of rice subjected to X-ray and thermal neutron irradiation, Beaumont, Texas, 1955

Variety and Type of Mutation	Number of Selections Showing Mutations When Treated With: Thermal Neutrons, hours 16	20	25	X-ray, r units 15,000	20,000	25,000	Total
Century Patna 231, grain longer	2	0	-	0	1	0	3
Bluebonnet 50, grain longer	3	2	0	0	2	1	8
Century Patna 231, grain shorter	9	0	-	4	3	4	20
Bluebonnet 50, grain shorter	4	3	1	1	4	2	15
Century Patna 231, hull color (straw)	13	1	--	0	2	1	17
Bluebonnet 50, hull color (gold)	1	0	0	0	0	0	1
Century Patna 231, taller plants	3	0	-	0	4	0	7
Bluebonnet 50, taller plants	4	1	0	1	1	2	9
Century Patna 231, shorter plants	3	8	-	5	7	7	30
Bluebonnet 50, shorter plants	27	16	11	10	20	9	93
Century Patna 231, sterile plants	13	10	0	3	0	3	29
Bluebonnet 50, sterile plants	10	10	6	5	10	7	48
Century Patna 231, rough hulls	0	0	-	0	0	0	0
Bluebonnet 50, rough hulls	0	1	0	0	0	1	2
Century Patna 231, shattering	0	0	-	0	0	1	1
Bluebonnet 50, shattering	1	0	1	1	0	1	4
Century Patna 231, narrow leaf	0	0	-	0	1	0	1
Bluebonnet 50, narrow leaf	0	1	1	0	0	0	2
Century Patna 231, weak or diseased	0	0	-	0	1	1	2
Bluebonnet 50, weak or diseased	3	4	1	2	1	2	13
Century Patna 231, leaf spot resistant	0	0	-	0	0	0	0
Bluebonnet 50, leaf spot resistant	0	0	0	0	3	1	4
Century Patna 231, chlorophyl deficient	1	0	-	0	1	4	6
Bluebonnet 50, chlorophyl deficient	2	0	0	0	0	1	3
Century Patna 231, glutinous	1	0	-	0	1	0	2
Century Patna 231, late plants	1	0	-	1	1	0	3
Bluebonnet 50, late plants	4	1	1	3	2	3	14

TABLE 1 - continued

Variety and Type of Mutation	Number of Selections Showing Mutations When Treated With: Thermal Neutrons, hours 16	20	25	X-ray, r units 15,000	20,000	25,000	Total
Bluebonnet 50, early plants	0	0	0	0	0	1	1
Bluebonnet 50, Tetraploid like	1	1	0	2	0	0	4
Bluebonnet 50, grassy dwarf	0	0	2	0	0	0	2
Bluebonnet 50, Sathi	0	0	0	0	0	1	1
Bluebonnet 50, bearded	0	0	0	0	0	1	1
Bluebonnet 50, red seed coat	0	1	0	0	0	0	1

With but one or two possible exceptions, all rows were still segregating for grain length in the X_3 generation.

A short grain mutation was found in Bluebonnet 50, a normally long-grain variety. The height of the plants of this mutation was slightly reduced in comparison with normal plants and the leaves and culms appeared to be slightly wider or thicker.

Hull Color

A rather large number of selections with straw-colored hulls were found in the X_2 and X_3 generations of the Century Patna 231 treatments. These variants were suspected of being natural crosses, but they were found in 4 of the 6 treatments but none were found in the check rows. Only one gold selection was found in Bluebonnet 50, a variety with straw colored hulls.

Plant Height

Most of the mutations involving plant height were shorter than normal, but a few plants taller than normal were observed. Many of the shortened plants also had a shortened grain.

One of the most interesting mutations observed was a very short plant which was near normal height in the early vegetative stages. The peduncle elongated to approximately three-fourths normal length, but the other internodes were only slightly elongated. As a result, the plants of this mutant were 12 to 14 inches shorter than normal plants. The panicles and grain appeared to be near normal length. Preliminary yield experiments conducted in 1956 indicate that this mutation is only slightly less productive than normal Century Patna 231.

A somewhat similar mutation was observed in Bluebonnet 50 in which all internodes and the peduncle showed only minor elongation. As a result, most of the panicles failed to emerge from the boot. In some plants the tips of the panicles emerged. Both of these mutations produced normal length grains. Crosses between these mutations and normal plants will be made to determine mode of inheritance for height.

The Bluebonnet 50 treatments produced other mutations 12 to 14 inches shorter than normal with no reduction in grain length. However, in these mutations all internodes elongated but not to the extent as exhibited by normal plants. Many of the short stature mutations appeared to be more susceptible to leaf spot diseases than normal plants.

Rough Hulls

Only two rough-hulled types were recovered in 1955 and both were from Bluebonnet 50. At least one of these had a red seed coat. Several such plants were found in 1954. They resembled natural crosses in that the plants were extremely vigorous.

Shattering

Mutations that shattered freely were found in both varieties in X_2 and were recovered in X_3. They were easily identified since most of the grain had shattered from the panicles when examined. Several shattering plants were present in the X_2 rows.

Narrow Leaf

A plant with extremely narrow leaves, small stems, and short stature was found in an otherwise normal row in the X_2 generation of Century Patna 231. Many normal plants were present in the narrow-leaf

X_3 rows in 1955, but most of the narrow-leaf rows were breeding true in 1956. It is suspected that the normals are natural crosses since the plants were very short and completely surrounded by taller, more vigorous plants, which would favor excessive cross pollination in 1953.

Weak or Diseased Plants

Many weak or disease-susceptible plants were found in the X_2 and X_3 generations. Frequently they were completely sterile. A few were recovered in 1955 from similar material found in 1954.

Chlorophyll-Deficient Plants

Several rows of both varieties that were segregating for albino and normal seedlings were found in 1955. This characteristic frequently occurs in rice but the rate of occurrence was possibly increased by the treatment as it was not noted in untreated check rows.

A number of other mutations that have been observed in commercial varieties also were observed. These included characters such as grassy dwarfs, sathi, early maturity, tetraploid-like and others. The X-ray and thermal neutron treatments produced similar variations in most cases and no conclusions were drawn as to whether one was more effective than the other.